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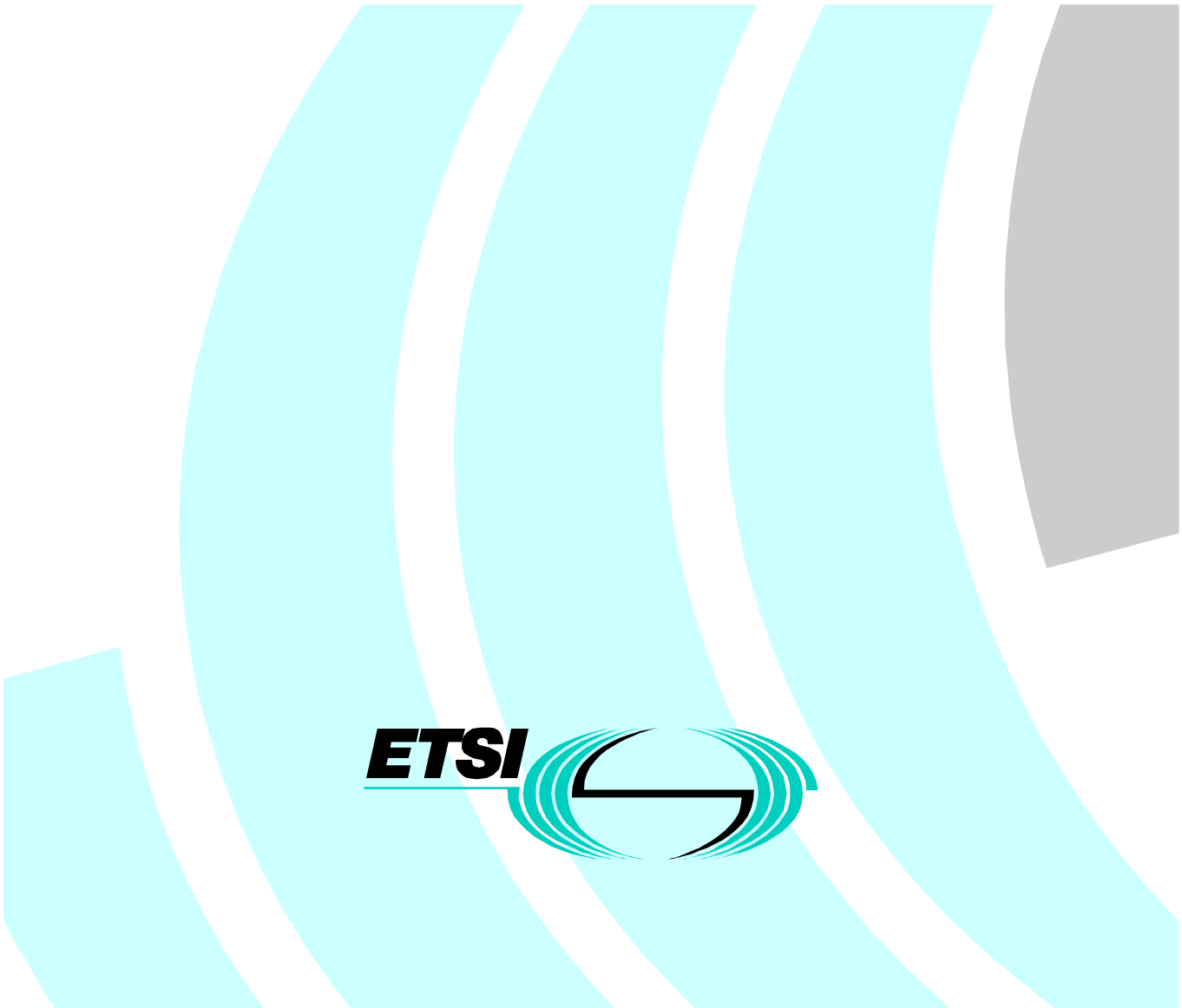
European Standard (Telecommunications series)

Fixed Radio Systems; Point-to-multipoint equipment; Point-to-multipoint digital radio systems in frequency bands in the range 24,25 GHz to 29,5 GHz using different access methods; Part 5: Multi-Carrier Time Division Multiple Access (MC-TDMA) methods



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Contents

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Foreword

This European Standard (Telecommunications series) has been produced by ETSI Technical Committee Transmission and Multiplexing (TM), and is now submitted for the Public Enquiry phase of the ETSI standards Two-step Approval Procedure.

The present document defines the requirements of radio terminal and radio-relay equipment and associated interfaces.

The present document is part 5 of a multi-part deliverable covering the Transmission and Multiplexing (TM); Digital Radio Relay Systems (DRRS); Point-to-multipoint DRRS in frequency bands in the range 24,25 GHz to 29,5 GHz using different access methods, as identified below:

Part 1: "Basic parameters" (EN 301 213-1 [1]);

Part 2: "Frequency Division Multiple Access (FDMA) methods" (EN 301 213-2 [2]);

Part 3: "Time Division Multiple Access (TDMA) methods" (EN 301 213-3 [3]);

Part 4: "Direct Sequence Code Division Multiple Access (DS CDMA) methods" (EN 301 213-4 [4]);

Part 5: "Multi-Carrier Time Division Multiple Access (MC-TDMA) methods".

Parts 2 to 5 are intended to be used in conjunction with part 1, describing the basic parameters common to all access methods.

A basic description of the different access methods and a comparison among them are provided in TR 101 274 [5].

The former title of the present document was: "Transmission and Multiplexing (TM); Digital Radio Relay Systems (DRRS); Point-to-multipoint DRRS in frequency bands in the range 24,25 GHz to 29,5 GHz using different access methods; Part 5: Multi-Carrier Time Division Multiple Access (MC-TDMA) methods ".

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	6 months after doa

1 Scope

The present document (Multi-Carrier Time Division Multiple Access Methods, MC-TDMA) is to be used in conjunction with EN 301 213-1 [1], describing the basic parameters common to all access methods.

The present document specifies the minimum requirements for system parameters of Multi-Carrier Time Division Multiple Access (TDMA) Point-to-Multipoint (P-MP) Radio Systems in the terrestrial fixed services operating in the band 24,5 GHz to 29,5 GHz (see CEPT Recommendation T/R 13-02 [6]). Only sections specific to TDMA are described in respect to the paragraphs stated in EN 301 213-1 [1].

Multi-Carrier Time Division Multiple Access (MC-TDMA) is an alternative to TDMA, FDMA and CDMA covered in other parts of the present document. In MC-TDMA point to Multipoint (P-MP) systems, a central station broadcasts information to terminal stations in a continuous Time Division Multiplex (TDM) or in a burst TDMA mode. The CRS and /or TS may transmit one or more sub-carriers at various frequencies, bandwidths, modulation and power levels, however the normative requirements relating to channel bandwidths and spectrum masks must be met. The Terminal stations transmit in TDMA mode. The users may have access to the spectrum by sharing it through time multiplexing.

The present version V.1.1.1 is a new draft which contains:

- Introduction of a Multi-Carrier TDMA system, where a single transmitter can transmit more than one sub-carrier.

2 References

The following documents contain provisions, which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

[1] ETSI EN 301 213-1: "Fixed Radio Systems; Point-to-multipoint equipment; Point-to-multipoint digital radio systems in frequency bands in the range 24,25 GHz to 29,5 GHz using different access methods; Part 1: Basic parameters".

[2] ETSI EN 301 213-2: "Fixed Radio Systems; Point-to-multipoint equipment; Point-to-multipoint digital radio systems in frequency bands in the range 24,25 GHz to 29,5 GHz using different access methods; Part 2: Frequency Division Multiple Access (FDMA) methods".

[3] ETSI EN 301 213-3: "Fixed Radio Systems; Point-to-multipoint equipment; Point-to-multipoint digital radio systems in frequency bands in the range 24,25 GHz to 29,5 GHz using different access methods; Part 3: Time Division Multiple Access (TDMA) methods".

[4] ETSI EN 301 213-4: "Fixed Radio Systems; Point-to-multipoint equipment; Point-to-multipoint digital radio systems in frequency bands in the range 24,25 GHz to 29,5 GHz using different access methods; Part 4: Direct Sequence Code Division Multiple Access (DS-CDMA) methods".

[5] ETSI TR 101 274: "Transmission and Multiplexing (TM); Digital Radio Relay Systems (DRRS); Point-to-multipoint DRRS in the access network: Overview of different access techniques".

[6] CEPT Recommendation T/R 13-02: "Preferred channel arrangements for the fixed services in the range 22,0 GHz to 29,5 GHz".

[7] ITU-R Recommendation F.1249: "Maximum equivalent isotropically radiated power of transmitting stations in the fixed service operating in the frequency band 25,25 - 27,5 GHz shared with the inter-satellite service.

3 Definition, symbols and abbreviations

See EN 301 213-1 [1], clause 3.

3.1 Definitions

For the purposes of the present document, the following definitions apply, in addition to clause 3 in EN 301 213-1 [1]:

gross-bit-rate: transmission bit rate over the air. In case of a transmitter working in burst mode the gross bit rate is the instantaneous maximum transmission bit rate during the burst. The gross bit rate has a unique relationship to the symbol rate through the implemented modulation format.

multi-carrier: system where more than one modulated sub-carrier is radiated from the same transmitter. A system that uses several transmitters into a non-active antenna is not considered as a multi-carrier system.

3.2 Abbreviation

For the purposes of the present document, the following abbreviations apply:

CSmin Minimum practical channel separation (for a given radio-frequency channel arrangement)

4 General characteristics

4.1 General System Architecture

See EN 301 213-1 [1], clause 4.1.

4.2 Frequency bands and channel arrangements

4.2.1 Channel plan

Bands allocated to the Fixed Service in the range 24,5 GHz to 29,5 GHz shall be used according to CEPT Recommendation T/R 13-02 [6], annexes B and C.

Regulatory bodies may choose appropriate parts of the above mentioned frequency bands for the application for Point-to-Multipoint systems.

4.2.2 Channel arrangements

The system shall meet at least one or more of the channel arrangements listed in table 1.

Table 1: Channel arrangement

Channel Spacing [MHz]	3,5 MHz	7 MHz	14 MHz	28 MHz	56 MHz	112 MHz
System Type A						
Minimum bit rate for transmission and reception (Mbit/s)	4 Mbit/s	8 Mbit/s	16 Mbit/s	32 Mbit/s	64 Mbit/s	128 Mbit/s
System Type B						
Minimum bit rate for transmission and reception (Mbit/s)	8 Mbit/s	16 Mbit/s	32 Mbit/s	64 Mbit/s	128 Mbit/s	256 Mbit/s
System Type C						
Minimum bit rate for transmission and reception (Mbit/s)	12 Mbit/s	24 Mbit/s	48 Mbit/s	96 Mbit/s	192 Mbit/s	384 Mbit/s

NOTE 1: The minimum transmission bit rate is defined as the gross bit rate of the multi-carrier system assumed as sum of all sub-carriers gross bit rate. The sum of all upstream sub-carriers' transmission bit rates for a fully equipped system shall meet the requirements for the system type declared by the manufacturer as per table 1. Where a different aggregate gross bit rate applies in each direction, the system type declared shall indicate this by giving the system type for the downstream followed by a hyphen and then the system type for the upstream. For example, a system conforming to type C in the downstream direction and type A in the upstream direction should be declared as a type C-A. Where the system type differs for upstream and downstream, the system shall meet all requirements for the declared system type for each direction.

NOTE 2: Systems may offer a combination of Type A, Type B, and Type C, provided that such a system, when operating in mixed mode, complies with the most stringent spectral mask for the types offered. A mix mode could consist of a system that operates with different system type on a per sub-carrier or time-slot basis or both.

NOTE 3 System Type A is primarily covering 4 state or equivalent modulation.
System Type B is primarily covering 16 state or equivalent modulation.
System Type C is primarily covering 64 state or equivalent modulation.
"or equivalent" means providing the same spectral efficiency and system performance regardless of the actual modulation scheme.

NOTE 4: For regulatory purposes in national procedures for licensing radio equipment according to the present document, the above system types shall be identified by the "system type codes" reported in Normative annex A.

NOTE 5: Allocated RF channels may be occupied by systems using any number of sub-carriers or size of sub-carrier bandwidth within a specific channel, as long as the spectrum mask for the allocated RF channel is not exceeded, for any configuration of sub-carriers

NOTE 6: The CRS transmission, defined as the "downstream" direction, may be continuous, i.e. TDM (Time Division Multiplex). The CRS may transmit in the downstream direction even if there are no active calls, for the purpose of synchronization of the Terminal Stations.
The Terminal Stations (TS) may transmit in timeslots allocated by control signals from the CS, or on a fixed basis. The TS transmission direction is defined as "upstream". A TS may transmit control, bandwidth requests or signalling information even during the absent of users activities. TS transmissions consist of bursts of fixed or variable duration, usually an integer multiple of a fundamental timeslot duration.

4.3 Compatibility requirements

See EN 301 213-1 [1], clause 4.3.

4.4 Environmental conditions

See EN 301 213-1 [1], clause 4.4.

4.5 Power supply

See EN 301 213-1 [1], clause 4.5.

4.6 Electromagnetic compatibility conditions

See EN 301 213-1 [1], clause 4.6.

4.7 TMN interfaces

See EN 301 213-1 [1], clause 4.7.

4.8 Synchronization of interface bit rates

See EN 301 213-1 [1], clause 4.8.

4.9 Branching/feeder/antenna requirements

See EN 301 213-1 [1], clause 4.9.

5 System parameters for MC-TDMA P-MP systems

NOTE: Where a reference is made to the number of states of a modulation scheme or to the system type class, an equivalent modulation scheme may be applied, provided the system parameters are met.

5.1 System capacity

See EN 301 213-1 [1], clause 5.1.

5.2 Round trip delay

See EN 301 213-1 [1], clause 5.2.

5.3 Transparency

See EN 301 213-1 [1], clause 5.3.

5.4 Voice coding methods

See EN 301 213-1 [1], clause 5.4.

5.5 Transmitter characteristics

See EN 301 213-1 [1], clause 5.5.

5.5.1 Transmitter output power

The total mean power of the composite multi-carrier system shall refer to EN 301 213-1 [1], clause 5.5.1.

5.5.2 Transmitter nominal output power

See EN 301 213-1 [1], clause 5.5.2.

The power output of the transmitter at point C and C' (see figure 2 of EN 301 213-1 [1]) shall be appropriate to the mode of use:

a) CRS, RS, or TS "broadcast mode". The power output shall be in conformance with EN 301 213-1 [1];

b) CRS, RS or TS operating in TDMA burst mode. The power output during a burst shall be in conformance with EN 301 213-1 [1]. The power may be controlled by ATPC;

c) The nominal power shall have a maximum tolerance, including setting errors, of ± 2dB for weather protected locations, ± 3dB for equipment in non weather protected locations and shall not exceed the maximum allowed transmitter output power.

NOTE 1: The spectrum mask requirement, which asks for a 2 dB differential tolerance among sub-carriers (clause 5.5.4), could require a coherent tolerance for all the sub-carrier.

NOTE 2: In case of similar sub-carriers, the nominal output power for each sub-carrier would be 1/N of the total nominal output power of the CRS referred to point C'.
In case of dissimilar sub-carriers the relative power of each sub-carrier would depend from the actual symbol frequencies (FS) and differ by a factor 10log (FS_1/FS_2).
Therefore, under operational conditions, the output power of some sub-carriers may be greater than 1/N of the nominal output power provided that the maximum average output power of +35 dBm is not exceeded and/or ITU-R Recommendation F.1249 [7] is fulfilled.

5.5.3 Transmitter power and frequency control

See EN 301 213-1 [1], clauses 5.5.3, 5.5.3.1, 5.5.3.2 and 5.5.3.3.

The RTPC function shall be common to all sub-carriers of the same transmitter (i.e. they are subject to the same attenuation)

The ATPC function may be implemented on a common or on a single sub-carrier base; in all cases the spectrum mask of clause 5.5.4 shall be met with the maximum provided output power of all sub-carriers.

5.5.4 RF spectrum mask

The 0 dB level shown on the spectrum masks is relative to the maximum of the modulated spectrum of the sub-carrier with the lowest spectral density, disregarding residual carriers.

When applying the spectrum mask, the spectral density of all sub-carriers shall be within 0 dB to 2 dB relatively to the reference level; see a generic example in figure 1.

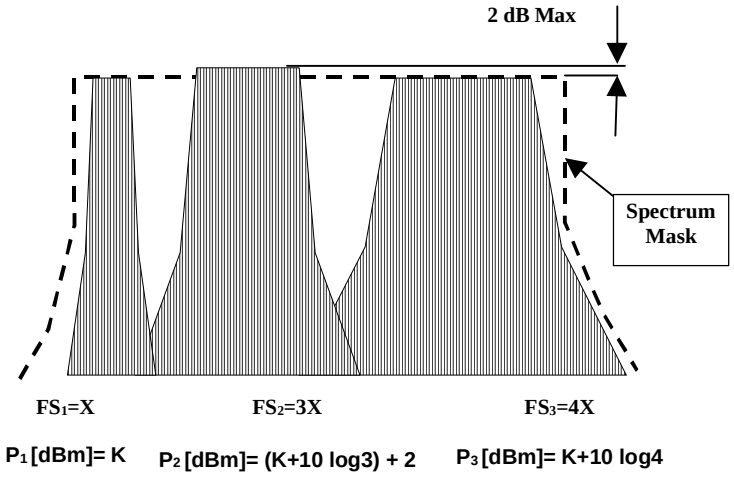


Figure 1: Example of three sub-carrier system with different symbol frequency (FS)

The masks do not include frequency tolerances.

5.5.4.1 RF spectrum density mask for the central radio station

General test load conditions to measure the spectrum mask for the CRS transceiver:

- the CRS transmitter shall work under full capacity load;
- the total output power level should be according to clause 5.5.2;
- all sub-carriers are modulated according to the input bit rate (referred to Z' in figure 2 of EN 301 213-1 [1]) declared by the manufacturer. The input signal shall be in accordance to the interfaces stated in table 2 of EN 301 213-1 [1];
- for systems that use mix mode, refer to note 2 of clause 4.2.2;
- the RF spectrum masks shown in figure 2 and table 2 below apply for multi-carrier TDMA systems:

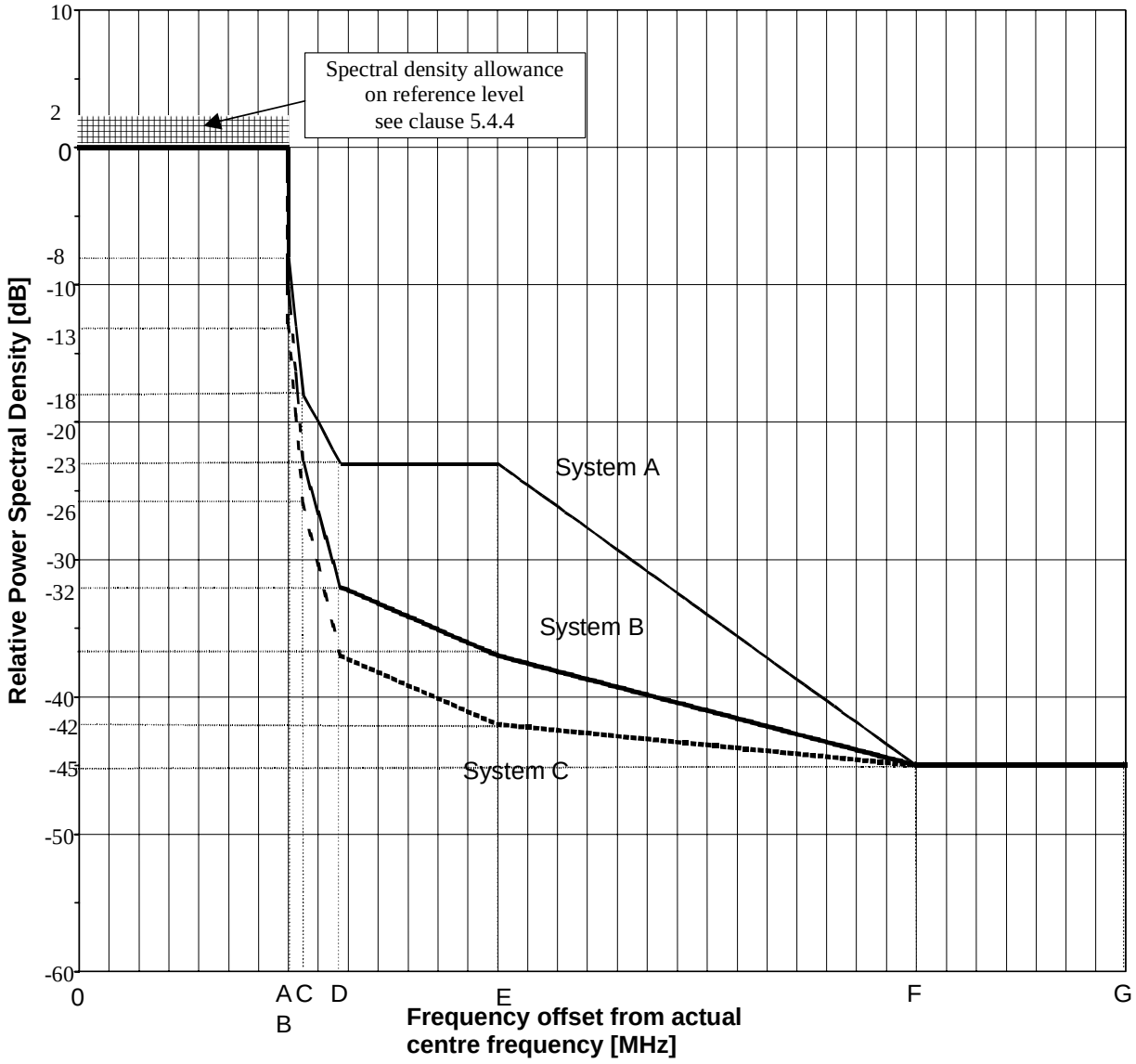


Figure 2: Spectrum masks of the composite multi-carrier system (fo = channel centre frequency)

Table 2: Spectrum masks of the composite multi-carrier system,

	Points in figure 2 (frequency) ↓						
Co-polar channel spacing ↓	**Point A [MHz]**	**Point B [MHz]**	**Point C [MHz]**	**Point D [MHz]**	**Point E [MHz]**	**Point F [MHz]**	**Point G [MHz]**
3.5 MHz	1.75	1.75	2	2.25	3.5	7	8.75
7 MHz	3,5	3,5	3,75	4,5	7	14	17.5
14 MHz	7	7	7.5	8.75	14	28	35
28 MHz	14	14	15	17.5	28	56	70
56 MHz	28	28	30	35	56	112	140
112 MHz	56	56	60	70	112	224	280
	Points in figure 2 (attenuation) ↓						
System Type A	0 dB	-8 dB	-18 dB	-23 dB	-23 dB	-45 dB	-45 dB
System Type B	0 dB	-10 dB	-23 dB	-32 dB	-37 dB	-45 dB	-45 dB
System Type C	0 dB	-13 dB	-26 dB	-37 dB	-42 dB	-45 dB	-45 dB

The spectrum analyser settings for measuring the RF-spectrum masks are listed in table 3.

Table 3: Spectrum analyser settings for RF power spectrum measurement

	Central Stations (CRS) and Repeater Stations (RS)						**Terminal Stations (TS)**
RF channel spacing. (MHz)	3,5	7	14	28	56	112	Any
Centre frequency	actual	actual	actual	actual	actual	actual	actual
Sweep width (MHz)	20	40	80	160	320	640	See corresponding CRS
Scan time	auto	auto	auto	auto	auto	auto	auto
IF bandwidth (kHz)	30	30	30	100	100	300	See note
Video bandwidth (kHz)	0,1	0,3	0,3	0,3	0,3	1,0	

NOTE: The spectrum analyser settings for RF power Spectrum Measurement for TDMA Terminal Stations (TS) are depending on the burst duration. For a burst duration of ≈ 50 µs the recommended settings are IF bandwidth ≈ 30 kHz and video bandwidth ≈ 10 kHz.
For other burst durations, the recommended settings are as following:
-IF bandwidth ≈ 30 kHz x 50 µs/(burst duration in us);
-Video bandwidth ≈ 10 kHz x 50 µs/(burst duration in us).
The supplier has to declare the burst duration.

5.5.4.2 RF-spectrum density mask for the terminal station

The RF spectrum masks for the TS shall comply with the spectrum mask of the CRS in figure 2, irrespective of the centre frequency of the TS sub-carrier.

5.5.4.3 RF-spectrum density mask for the repeater station

The RF spectrum masks for the RS shall comply with the spectrum mask of the CRS in figure 2, irrespective of the centre frequency of the RS sub-carriers.

5.5.4.4 Discrete CW components exceeding the spectrum density mask limit (all stations)

In case some CW components exceed the spectrum mask, an additional allowance is given.

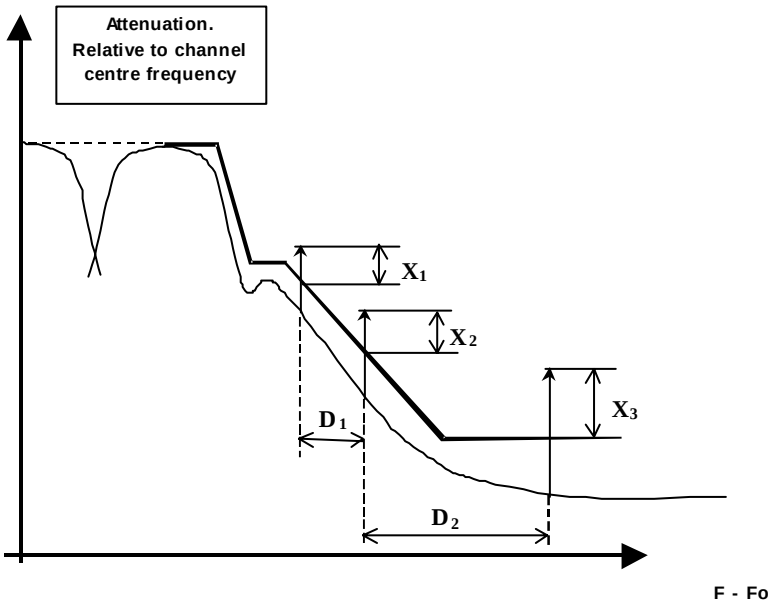
Those lines shall not:

- exceed the mask by a factor more than {10 log (CSmin/IFbw) - 10} dB;
- be spaced each other in frequency by less than CSmin.

Where:

- CSmin is the minimum practical channel separation for the given radio-frequency channel arrangement;
- CSmin = 1 750 kHz for both 26 GHz and 28 GHz bands;
- IFbw is the recommended resolution IF bandwidth, expressed in kHz, reported in table 3.

Figure 3 shows a typical example of this requirement.



X_1, X_2, X_3 [dB] $\leq 10\log(CSmin/IFbw) - 10$

$D_1, D_2 \geq CSmin$

Figure 3: CW lines exceeding the spectrum mask (typical example)

5.5.5 Tx local oscillator frequency arrangements

See EN 301 213-1 [1], clause 5.5.5.

5.5.6 Spurious emissions (external)

See EN 301 213-1 [1], clause 5.5.6.

5.5.7 Radio frequency tolerance

See EN 301 213-1 [1], clause 5.5.7.

5.6 Receiver characteristics

See EN 301 213-1 [1], clause 5.6.

5.6.1 Rx local oscillator frequency arrangements

See EN 301 213-1 [1], clause 5.6.1.

5.6.2 Spurious emissions (external)

See EN 301 213-1 [1], clause 5.6.2.

5.6.3 Receiver IF

See EN 301 213-1 [1], clause 5.6.3.

5.7 System performance

All parameters are referred to reference points B or C of figure 2 of EN 301 213-1 [1]. All measurements shall be carried out with the test signals defined in clause 5.5 of EN 301 213-1 [1] and under full load conditions.

5.7.1 Dynamic level range

The dynamic level range shall be declared by the manufacturer at a BER of $\leq 10^{-3}$.

5.7.2 BER as a function of Receiver input Signal Level (RSL)

The input signal level of each sub-carrier presented to the receiver under test is adjusted to the levels calculated as described in the formulas below for the actual bit rate of the sub-carrier. The BER for each sub-carrier within a channel shall be less than or equal to the values defined in the formulas. For the purposes of testing, the transmitter is operated at its maximum rated power level declared by the manufacturer.

Based on the actual bit rates, the relevant receive levels of each sub-carrier shall be calculated according to the following formulas:

- System Type A:

  $RSL_{(\text{for BER } 10^{-3})}$ (dBm) = -92 + 10 × log b;

  $RSL_{(\text{for BER } 10^{-6})}$ (dBm) = -88 + 10 × log b.

- System Type B:

  $RSL_{(\text{for BER } 10^{-3})}$ (dBm) = -87+ 10 × log b;

  $RSL_{(\text{for BER } 10^{-6})}$ (dBm) = -83+ 10 × log b.

- System Type C:

  $RSL_{(\text{for BER } 10^{-3})}$ (dBm) = -81.8 + 10 × log b;

  $RSL_{(\text{for BER } 10^{-6})}$ (dBm) = -78.8 + 10 × log b.

b = bit rate (Mbit/s) (actual gross bit rate of each sub-carrier).

The effect of differential attenuation of the sub-carriers, due to different rain intensity within the sector and/or ATPC, shall be taken into account. Therefore the above requirement shall be met with the adjacent sub-carrier transmitter(s) operating at the maximum declared power level and the adjacent sub-carrier(s) RSL set to the higher differential power, with respect to the sub-carrier under actual measurement, permitted by the system implementation, as declared by the supplier.

5.7.3 Equipment Residual BER

See EN 301 213-1 [1] clause 5.7.3.

The requirement shall be met by each sub-carrier.

The effect of differential attenuation of the sub-carriers, due to different rain intensity within the sector and/or ATPC, shall be taken into account. Therefore the above requirement shall be met with the adjacent sub-carrier(s) RSL set to the higher differential power, with respect to the sub-carrier under actual measurement, permitted by the system implementation, as declared by the supplier.

5.7.4 Interference sensitivity

5.7.4.1 Co-channel interference (external)

The limits of co-channel interference (external from a like multi-carrier interfering signal) shall be as in table 4, giving maximum S/I values for 1 dB and 3 dB degradation of the 10^{-6} BER limits specified in clause 5.7.2. Limits shall be met for each sub-carrier.

Table 4: Co-channel interference sensitivity

Description	BER = 10^{-6}	
Threshold degradation	1 dB	3 dB
Signal to Interference level	S/I [dB]	S/I [dB]
System Type A	23	19
System Type B	30	26,5
System Type C	36	32,5

5.7.4.2 Adjacent channel interference (external)

The limits of adjacent channel interference (external from a like multicarrier interfering signal) shall be as given in table 5 for like modulated signals, giving maximum S/I values for 1 dB and 3 dB degradation of the 10^{-6} BER limits specified in clause 5.7.2. Limits shall be met for each sub-carrier.

The requirement shall be met for an interfering signal on either side of the multicarrier system centre frequency.

Table 5: Adjacent channel interference sensitivity

Description	BER = 10^{-6}	
Threshold degradation	1 dB	3 dB
Signal to Interference level	S/I [dB]	S/I [dB]
System Type A	0	-4
System Type B	0	-4
System Type C	0	-4

5.7.4.3 CW interference

See EN 301 213-1 [1], clause 5.7.4.3.

5.7.5 Distortion sensitivity

See EN 301 213-1 [1], clause 5.7.5.

6 Types of interfaces at the user equipment and the network node

See EN 301 213-1 [1], clause 6.

Annex A (normative): System type codes for regulatory procedures

System types reported in the present document, shall be identified with the codes reported in table A.1.

Table A.1: System type codes for radio equipment reported in EN 301 213-5, relevant to regulatory procedures for national licensing

System type ↓	Channel spacing [MHz] ↓	CRS Bit-rate [Mbit/s] ↓	Frequency band (see note) ↓	System type codes ↓
A	3.5	4	B1	01
			B2	02
	7	8	B1	03
			B2	04
	14	16	B1	05
			B2	06
	28	32	B1	07
			B2	08
	56	64	B1	09
			B2	10
	112	128	B1	11
			B2	12
B	3.5	8	B1	13
			B2	14
	7	16	B1	15
			B2	16
	14	32	B1	17
			B2	18
	28	64	B1	19
			B2	20
	56	128	B1	21
			B2	22
	112	256	B1	23
			B2	24
C	3.5	12	B1	25
			B2	26
	7	24	B1	27
			B2	28
	14	48	B1	29
			B2	30
	28	96	B1	31
			B2	32
	56	192	B1	33
			B2	34
	112	384	B1	35
			B2	36

NOTE: Option B1 refers to systems operating in frequency band 24500-26500 MHz (ERC Recommendation T/R 13-02 [6], annex B).
Option B2 refers to systems operating in frequency band 27500-29500 MHz (ERC Recommendation T/R 13-022 [6], annex C).

Annex B (informative): Bibliography

- ETSI ETS 300 019: "Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment".
- ETSI EN 300 339: "Electromagnetic compatibility and Radio spectrum Matters (ERM); General ElectroMagnetic Compatibility (EMC) for radio communications equipment".
- ETSI ETS 300 385: "Radio Equipment and Systems (RES); ElectroMagnetic Compatibility (EMC) standard for digital fixed radio links and ancillary equipment with data rates at around 2 Mbit/s and above".
- ETSI EN 300 833 (V1.2.1): "Fixed Radio Systems; Point to Point Antennas; Antennas for point-to-point fixed radio systems operating in the frequency band 3 GHz to 60 GHz".
- ETSI EN 301 021 (V1.3.1): "Fixed Radio Systems; Point-to-multipoint equipment; Time division Multiple access (TDMA); Point-to-Multipoint digital radio systems in frequency bands in the range 3 GHz to 11 GHz".
- ETSI EN 301 132 (V1.1): "Integrated Services Digital Network (ISDN); Security tools (SET) for use within telecommunication services".
- ETSI EN 301 390 (V1.1.1): "Fixed Radio Systems; Point-to-point and Point-to-Multipoint Systems; Spurious emissions and receiver immunity at equipment/antenna port of Digital Fixed Radio Systems".
- IEC Publication 154-2: "Flanges for wave guides, rectangular".
- ITU-T Recommendation G.131: "Control of talker echo".
- ITU-T Recommendation G.711: "Pulse code modulation (PCM) of voice frequencies".
- ITU-T Recommendation G.726: "40, 32, 24, 16 kbit/s Adaptive Differential Pulse Code Modulation (ADPCM)".
- ITU-T Recommendation G.728: "Coding of speech at 16 kbit/s using low-delay code excited linear prediction".
- ITU-T Recommendation G.729: "Coding of speech at 8 kbit/s using conjugate-structure algebraic-code-excited linear prediction (CS-ACELP)".
- ITU-T Recommendation G. 773: "Protocol suites for Q-interfaces for management of transmission systems".
- ITU-T Recommendation G.810: "Definitions and terminology for synchronization networks".
- ITU-T Recommendation G.812: "Timing requirements of slave clocks suitable for use as node clocks in synchronization networks".
- ITU-T Recommendation G.813: "Timing characteristics of SDH equipment slave clocks (SEC)".
- ITU-T Recommendation G.823: "The control of jitter and wander within digital networks which are based on the 2 048 kbit/s hierarchy".
- ITU-T Recommendation G.825: "The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)".
- ITU-T Recommendation O.151: "Error performance measuring equipment operating at the primary rate and above".
- ITU-T Recommendation O.181: "Equipment to assess error performance on STM-N interfaces".

History

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